

NSAR in Concrete Slabs

By Peter Craig, Dennis Pinelle, Mauro Scali, and Matt Sherman

Q Over the years, we have had a number of call-backs on projects where our epoxy coating applications had developed fluid-filled blisters. When we had these problems investigated, we found that osmosis was most likely the cause.

Lately, a number of the forensic experts who have viewed similar troubled projects have suggested that alkali silica reaction (ASR) in the near-surface region of the concrete could be the cause of the blistering.

Conventional understanding has always dictated that when potentially reactive aggregates are present, ASR should take many years to develop. Yet these blistering conditions have developed in a relatively short period of time.

Can ASR develop in the near-surface region of a concrete slab and contribute to the blistering of polymer coatings applied to a concrete slab surface?

A There is growing evidence that suggests an alkali-related reaction called ASR can occur in the near-surface region of a concrete slab. When it occurs, the reaction can contribute to the blistering and disbondment of low-permeance coating systems. To differentiate this near-surface reaction from conventional ASR, we have named this condition near-surface alkali reaction (NSAR). Many consultants are currently studying this failure condition.

Q We've heard of ASR, but we thought that ASR was only associated with larger, coarse aggregate particles. Since the coarse aggregate is not normally exposed in the upper crust of a slab, how can ASR be a cause of blistering?



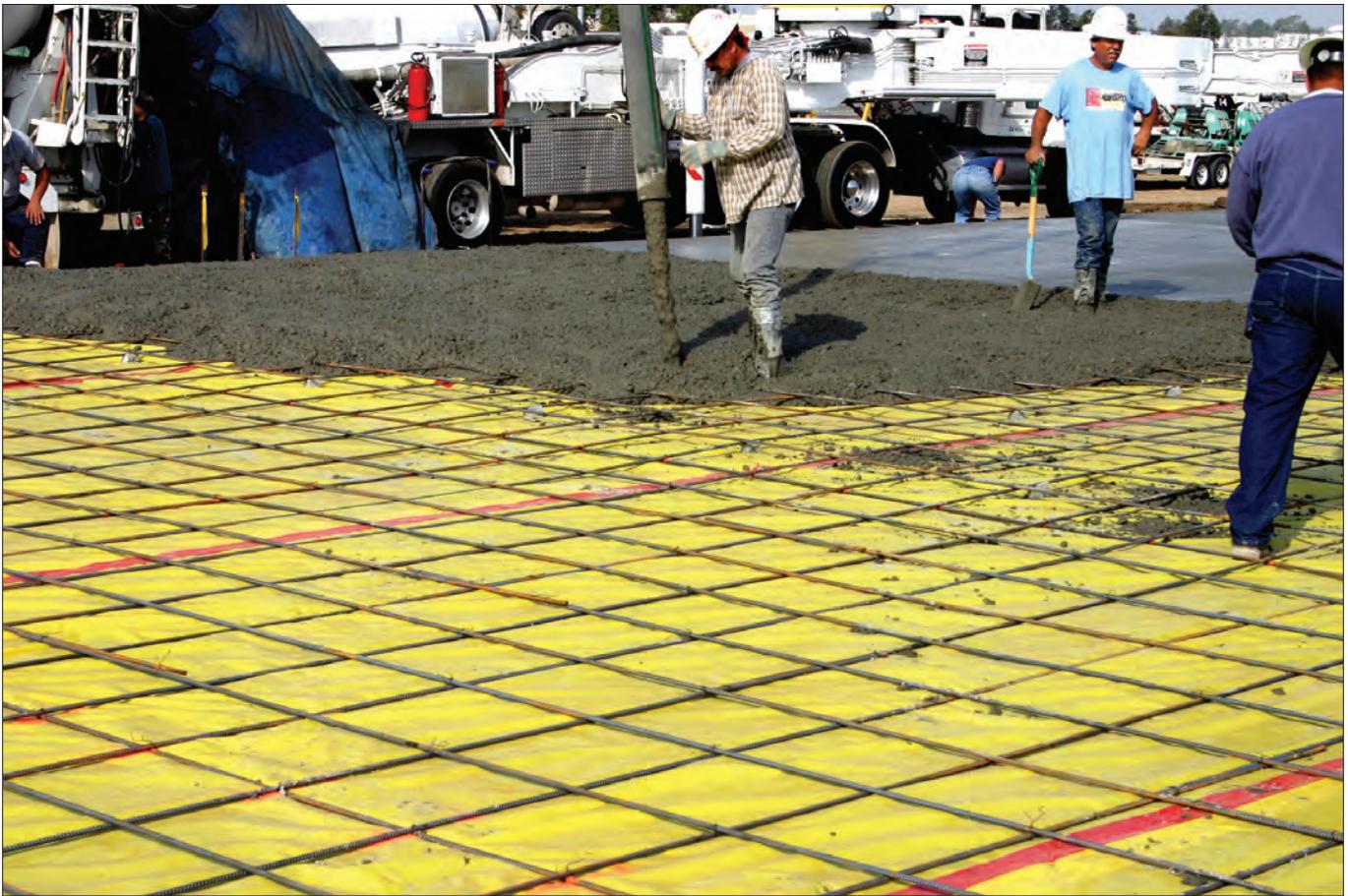
Alkali silica reaction (ASR) occurring near the surface of concrete can cause blistering and disbondment of low-permeance coating systems.

A It appears that the alkali-related reaction associated with coating failures is occurring with fine aggregate particles in the top $\frac{1}{16}$ to $\frac{3}{16}$ inches of the near-surface region of the concrete. In fact, near surface alkali reactions may be a greater problem than first supposed. Such reactions occur in the contact area of the cement paste to the aggregate's surface. Since there's a larger total surface area of fine aggregate particles in this near-surface region of a concrete slab, there's

a greater potential of alkali-related chemical reactions.

Q Does it take years for a near-surface alkali reaction to develop beneath a floor coating system?

A No. Textbooks and articles often report that conventional ASR takes many years to develop and cause internal cracking within a concrete member. We recently have studied alkali-related conditions associated with the blistering



A low-permeance vapor barrier/retarder installed directly beneath the concrete can take moisture from the ground out of play.

of a coating system that occurred in a much shorter time than a conventional ASR reaction.

Q What is necessary for a near-surface alkali reaction to develop beneath a coating system?

A When a concrete slab on ground is not constructed with an effective, low-permeance vapor barrier/retarder placed directly in contact with the underside of the slab, moisture from the ground will enter and migrate upward through the concrete until it is prevented from escaping by a low-permeance flooring or coating material that forms a vapor retarder on top of the slab. As moisture collects beneath the flooring material, soluble alkalis within the concrete paste are dissolved, creating a high pH environment at the interface of the floor coating system and the concrete.

When a high-pH solution forms and is contained within the near-surface

region of a concrete slab, alkali-related reactions, including those associated with potentially reactive fine aggregate particles, can occur.

Q Can ASR or NSAR account for the buildup of fluid under pressure that we observe in the blisters?

A When the gel that forms from an ASR reaction absorbs moisture, it swells and can create pressures great enough to crack concrete. However, it appears that the process of osmosis causes the buildup of fluid and pressure within the blisters. If present, the expansive force of ASR gel in the near-surface region may create small fractures and planes of weakness within the concrete surface. While osmotic cells can develop without ASR or NSAR being present, their reaction products may act as a solute in an osmotic cell and should be looked for during blister fluid analysis.

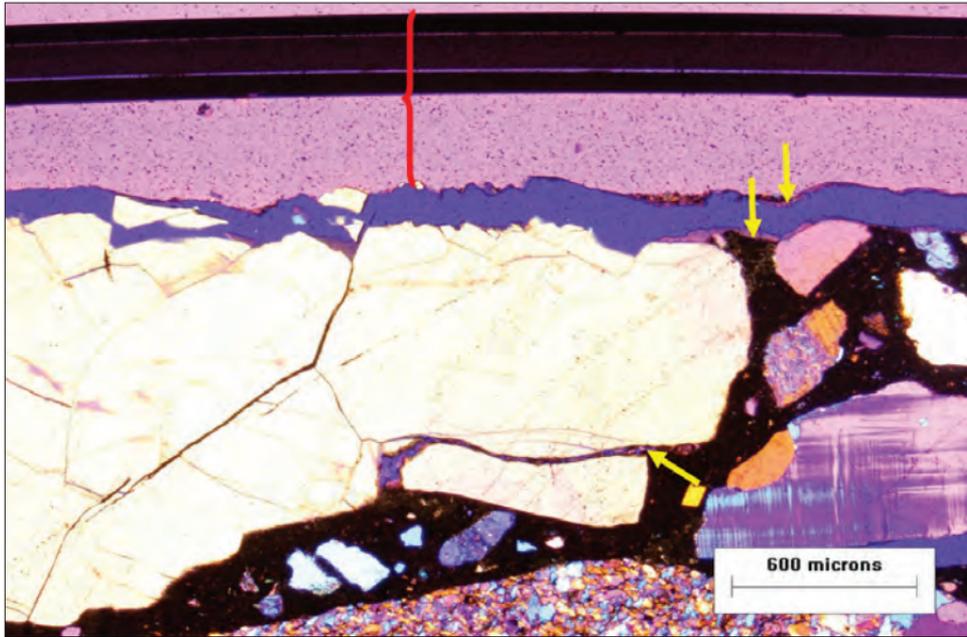
Q What can we do to avoid the potential for ASR, NSAR, or osmosis from occurring on our future projects?

A Make certain the concrete contains aggregates that are tested and shown to be stable in a high-alkali environment. Most ready-mixed concrete producers test their coarse and fine aggregate sources for potential reactivity.

Be certain to receive documentation that the concrete contains aggregates that comply with the appropriate ASTM methods, including ASTM C 1260, "Standard Test for Potential Reactivity of Aggregates," and show no potential for ASR.

Make sure that moisture from the ground is taken completely out of play by installing a low-permeance vapor barrier/retarder directly beneath the surface.

Today, there are materials available for such use with permeance levels of 0.01 perms and below. For an osmotic



Magnified 25X, the near surface area of a concrete slab beneath a blister in low-permeance coating. The red bracket highlights coating layers. ASR gel (yellow arrows) fills fractures in reactive strained quartz particle and partially lines top and bottom of blister fracture. Blue dye epoxy highlights areas of fractures not filled with ASR gel.

80% when moisture equilibrium is reached throughout the slab. Deny potentially reactive aggregate moisture, and alkali reaction will not develop or continue.

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cell to develop in concrete, abundant water must be present.

As is the case with many flooring and coating issues, if you get rid of the excess moisture, you get rid of the problems.

Before installing a low-permeance coating system, allow the concrete to dry to an internal relative humidity that does not exceed 75% when tested according to ASTM F 2170. The intent is to keep the concrete internal relative humidity below